Mitigation measures to climate change pdf

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Widespread use of fossil fuels releases large amounts of carbon in the atmosphere, which is the main cause of global warming. The amount of carbon dioxide emitted can be reduced by a variety of methods, but in a new study, researchers have found that capturing it underground can help solve climate problems. The study suggests that captured carbon from power plants and industrial plants could be stored in pockets about a mile underground. Researchers argue that their carbon capture and storage method (CCS) could make a significant contribution to the goal of reducing emissions by 13% by 2050, set by the United Nations Intergovernmental Panel on Climate Change (IPCC) under a 2 degree scenario. Researchers in their study published in the journal Scientific Reports explain the use of geological spaces that can store emissions around the world. They described the development of CO2 injecting wells based on oil industry data and developed the timing and number of wells to be developed. SEE ALSO: Scientists have developed bacteria that can eat carbon dioxide Researchers in their study explained that about 10 to 14,000 c2 injectable wells should be created worldwide by 2025, which can store 6 to 7 gigatn carbon dioxide each year. The number of wells to be built by 2050 to achieve the goals of The Grade 2 scenario may seem like a lot, but the study's lead author Philip Ringrose described it as very doable. He explained that about 2,000 injectable wells on the continent (about

14,000 in total) are only a small fraction of the number of wells developed by the oil industry in the last century. Co-author Type Meckel explained in his statement: We have shown that geology and speed of development can meet the goal, it is a very pragmatic way to go after that. SEE ALSO: More than 11,000 scientists announce Earth faces climate emergency chart through cdc. Climate change is certainly happening, but it does more than warm up the planet - it also affects our well-being. A new report from the American Psychological Association explains how climate change is gradually affecting our mental health. New data presented today by NOAA and NASA shows that global temperatures have reached record highs for ... Read more for the report, put together in collaboration with Climate Health and Eco-America, the ever-changing weather is a formidable source of stress many of us don't think. As climate change affects our agriculture, economy and communities, stress-inducing side effects seep towards us. For those exposed to the chaos of natural disasters, it is still worse. They experience fear, grief, anxiety, depression, and tend to retreat to unhealthy behaviors like substance abuse after such tragic events. Some even develop post-traumatic stress disorder, which take years of therapy to manage. And the report says that people forced to migrate due to natural disasters or other causes related to climate change often experience a strain on their personal relationships, loss of social support, and tend to have more absences at work. But even if you don't experience natural disasters first hand, you constantly hear about them, and that bombardment of depressing news can be enough to tip the scales of stress in your brain. And the effects of climate change reach us in more subtle ways as well. Seasonal weather, for example, plays a much bigger role in your mood than you might realize. Seasonal affective disorder (SAD) can strike during abnormally long winters, and it has been suggested that prolonged exposure to warm weather, as during unusually hot summers, can make you more aggressive and reduce cognitive function. Stress is an unpleasant fact of life. We all experience it for different reasons and we all try... Read moreAll in general, the fast-changing climate feels like a complete loss of control in our environment, and we struggle emotionally as we feel like we are not adapting well enough. The uncertainty of climate change seems to be piling up on top of our usual day-to-day stresses, pushing us to a potentially unhealthy threshold. Tackling this kind of stress is all about building and maintaining strong social connections, the report says. Saying things makes people feel safer, and a larger social support system makes sharing vital information easier. Another key is awareness. Just knowing that climate change can affect stress levels will give you a start so you can find your own ways to cope. This is especially true for those who live in areas where their livelihoods depend on the environment. Places where agriculture, tourism, fishing, outdoor recreation, etc., are the lifeblood of the community need to take extra care when dealing with these issues. You can check the full report yourself here. Doing your best not to chase current events can often feel like drowning in a stream ever... More Iceland cold. But it sits atop one of the hottest underground regions in the world, giving the country the ability to tap into the massive resythermal energy wrested by live volcanoes under the feet of Icelanders. Drill down only a few hundred meters, and trapped water will come gushing like high temperature steam. It's easy enough to turn into electricity: just run it through a turbine to drive an electric generator, as we've done for over 100 years with any kind of steam. The only problem is these volcanic regions also release carbon dioxide, the main greenhouse gases driving global climate change. Geothermal energy is still very clean, producing only 3% of emissions from a coal-fired power plant that generates the same energy. But But reduce emissions to zero. The solution can be found at the Geothermal Power Station Hellisheidi, Iceland's largest, near the capital Reykjavik. Since 2014, the plant has extracted heat from the ground, capturing the carbon dioxide released in the process, mixing it with water, and injecting it back underground, about 700 meters (2,300 feet) deep. Carbon dioxide in water reacts with minerals at this depth to form a rock where it remains trapped. In other words, Hellisheidi is now a zero-emissions plant that turns greenhouse gas into stone. In October this year, the company went even further, partnering with Swiss start-up Climeworks to install a machine that sucks carbon dioxide out of the air. This gas is also sent underground, where it too eventually turns to stone. The result is a negative emissions power plant that literally subtract carbon dioxide from the atmosphere. At the time of writing, the Climeworks machine had already pulled more than 5 metric tons of carbon dioxide out of the air and injected it underground, which is equivalent to burying the family's annual carbon footprint in India.Critics laughed at those who conducted a moonshot in a direct air grab only a decade ago. Currently, Climeworks is one of three startups, along with Carbon Engineering in Canada and Global Thermostat in the US, that have shown that the technology is feasible. Hellisheidi Carbon Sucking Machine is the second Climeworks installed in 2017. If it continues to find money, the startup hopes its installations will capture as much as 1% of annual global emissions by 2025, sequestering about 400 million metric tons of carbon dioxide per year. For decades, some scientists have hoped that carbon capture technologies deployed on a large scale would save humanity from catastrophic climate change by providing a bridge to a future in which we will have ample opportunity to create, store and supply all the world's energy from renewable sources alone. Now it seems inevitable. The 2015 Paris climate agreement set a series of goals aimed at preventing global averages from rising above 2 degrees Celsius compared to pre-industrial levels - a threshold beyond which irreversible climate change can be uttered. The main body on the issue, the Intergovernmental Panel on Climate Change, has swindled hundreds of possible futures to find economically optimal ways to achieve these goals, which require the world to nullify emissions by about 2060. In almost all IPCC models, carbon capture is absolutely necessary, no matter what else we do to mitigate climate change. But carbon capture technologies have been tormented Although first developed almost 50 years ago, their use in climate change mitigation only began in earnest in the 1990s and scaling them did not go as planned. Over the years billions of dollars have been spent on carbon capture projects that have not materialized. The latest failure was the $7.5 billion Kemper project in Mississippi, whose owners announced earlier this year that instead of finishing a planned low-emissions coal-fired power plant, they would simply turn it into a natural gas plant. These debacle have provided ammunition for environmental activists who argue that carbon capture technologies pose a moral hazard, making us complacent about the continued use of fossil fuels and extending the time we take to weed them off. At the latest climate talks in Bonn, Germany in November, protesters crowded only with U.S. panels officially hosting because some of the panellists advocated the use of carbon capture when burning coal. Pure coal is a myth! They shouted. After a year of reporting, I have come to the conclusion that carbon capture is vital and viable. My initial perception of carbon capture, based on what I read in the press, was toward the protesters. Carbon capture technologies seemed outrageously expensive, especially when renewable energy began to become cheaper to compete with fossil fuels. At the same time, my training in chemical engineering and chemistry told me that the technology was scientifically sound. And some of the world's most important climate change bodies continue to insist that we need carbon capture. Who should I believe? The question took me down a rabbit hole. After a year of reporting, through visits to large and small carbon capture plants around the world, and interviews with more than 100 scientists, entrepreneurs, policy experts and government officials, I have come to the conclusion that carbon capture is vital and viable. Its massive deployment remains challenging, but not for reasons that many environmentalists usually cite. Figuring out these misunderstandings can give hope to a world full of doom-and-gloom climate stories. Over the next two weeks, Kwartz will publish a series of articles exploring carbon capture technologies from China to California, demonstrating an important but poorly understood part of the global race to zero emissions. These are the stories of persistent environmentalists who are taking a different approach to addressing the biggest global threat humanity has ever faced, and a new kind of energy entrepreneur trying to convert carbon dioxide from responsibility into an asset. This article is part of the race for the zero-emissions series. The reporting was supported by fellowships from the McGraw Center for Business Journalism at The City University of New York's Graduate School of Journalism. The carbon capture case Will be the first elephant address in the room. agree that if we have to burn fossil fuels, we should use carbon capture technologies to nullify greenhouse gas emissions. But why should we continue to burn fossils many countries, even without subsidies, solar and wind power are beginning to compete with fossil fuels for the price. The trend indicates the world is awash with renewable energy not too many years. Moreover, there is now no doubt that the anger of some fossil fuel companies has delayed efforts to take global action to combat climate change. Why should we develop technologies that will help them now? The optimism associated with renewable energy masks some of the harsh realities. Despite years of progress, about 80% of the world's energy still comes from fossil fuels, as it did in the 1970s. Since then, we have continued to add renewable capacity, but this does not outpace the growth of the world's population and its demand for energy. Today, about 30% of the world's energy (and 40% of the world's electricity) comes from coal, which emits more carbon dioxide per unit of energy produced than almost any other fuel source. In a recent analysis (paywall), Deborah Adams of the International Energy Agency, an intergovernmental think tank, notes that global demand for coal actually increased in 2017. (And it's no surprise that global annual emissions across the country will increase and set a new record.) New coal-fired power plants are being built in most poor countries because coal is a relatively cheap, easily accessible, safe and reliable source of energy, she writes. The coal-fired power plant is a massive investment and usually has been operating for 40 years. This means that coal will remain a significant part of the energy balance for decades. The extremely valuable oil and gas industry, which accounts for 33% and 24% of the world's total energy consumption, is also entrenched, respectively. Based on what we know now, we will need major technological breakthroughs or weak global growth, including for large emerging and emerging economies, to make oil demand peak in the next 20 years, said Gian Maria Milesi-Ferretti of the International Monetary Fund. Despite the growth of electric cars, most oil companies agree that peak oil is not in sight. Even the head of the International Renewable Energy Agency, whose job it is to ensure that its more than 180 member countries reach 100% renewable energy, isn't exactly gung-ho about the prospects. In the electricity industry, 100% of renewable energy can still be achievable by 2050 or 2060, Adnan Amin told me, but it's unlikely to happen for all energy consumption. The global electricity sector accounts for only about 25% of all emissions. To help us solve the challenge when it comes to we've created a simulation in which your goal is to reduce global emissions to zero as soon as possible. You can either discourage energy sources that produce carbon dioxide or stimulate clean energy sources, or some combination of both. Forecasts are based on an open source tool, En-ROADS, built by Climate Interactive and MIT Sloan, a non-profit organization that simulates the impact of subsidies and taxes on energy consumption and carbon emissions. As you may have gathered, there is no way to achieve zero emissions through subsidies and taxes that are within that that would reasonably ensure that the global economy does not come to a complete halt. (For example, for coal, they will range from ± $80 per metric ton of CO_2 emissions). You need something else to cut emissions. Carbon capture technologies are important. If you're still unsure, think about it: There are several industries needed for a modern lifestyle that generate large amounts of carbon dioxide as a by-product of the chemistry of their manufacturing process. These carbon-intensive industries, including cement, steel and ethanol, produce about 20% of all global emissions. If we want to continue to use these products and achieve zero emissions, the only option is for these industries to deploy carbon capture. And we must achieve zero emissions, not only in the energy sector, but in full, in all industries and in all countries of the world. The last time there was so much carbon dioxide in the Earth's atmosphere was more than 800,000 years ago, when the world's sea level was 10 meters higher than it is today. Even conservative estimates of a world of 2 degrees Celsius suggest that by 2100 the oceans could rise more than one metre from today's levels, which could displace up to 10% of the world's population. It will also increase the frequency of heat and storm intensity while reducing yields. It's not something we can wait out. In theory, there are many ways to get to zero emissions. But time is running out, and this has forced many environmentalists to advocate for an ever-higher option where every technology that can cut emissions without pulling down the world economy should be offered a chance to thrive: from energy efficiency and renewable energy to nuclear power and carbon capture. By choosing the winners we needTechnology development has and continues to improve the lives of billions. Many of these advances have not required government support to become a reality, but no energy technology in recent history has been deployed on a large scale without significant help from a benefactor who can take the risk of investing tens of billions of dollars without guaranteed success. After World War II, countries capable of building nuclear weapons began to see nuclear energy as a strategic goal. Governments supported early research, transferred military know-how to handle radioactive materials to the private sector, and provided generous Support. The combination has created a successful private industry that can now build nuclear power plants anywhere In the 1970s, Japan became dangerously dependent on imports of large quantities of coal and oil. Huge natural gas deposits were discovered in Asia, but at the time there was little understanding of how to liquefy and safely transport large amounts of material. Japan has almost unilaterally absorbed the risks associated with nascent technology and created the liquefied natural gas industry that we know today. The latest example that will resonate with anyone who believes in the value of renewable energy is the story of how Germany came to be responsible for the solar energy revolution we live through today. Since 2000, the German Renewable Energy Act requires that electricity from renewable sources be a priority compared to all other sources in the country. The German government also set a fixed price for renewable electricity, and provided low-cost loans to homeowners for installing rooftop solar panels. The combination of incentives suddenly created a huge market for solar panels that were still expensive at the time. At some point, Germany is buying almost half of the world's solar cell reserves. Huge demand has pushed innovation and gradually lowered the price, and today the whole world is reaping the benefits of Germany's efforts. These examples show that national Governments, perhaps even one rich country, can fundamentally change the way the world produces energy. All these events were strategically important at the time. As we enter the first few years of sincere attempts to achieve zero global emissions, the time has come for the strategic development of carbon capture technologies. Flickr/Roy Luck according to CC BY 2.0WA parish power station, with train carriages supplying coal. There's a fixJust outside Houston, Texas, spread over an area of 4,300 acres (more than 3,500 football fields), is a WA parish generating station. It consists of four gas-fired power plants and four coal-fired power plants producing 3,700 MW of energy, enough to meet the energy needs of 3 million U.S. households. The power plant is so large that it has its own railway station, where two to three times a day dozens of wagons unload 15,000 metric tons of coal from the Powder River basin of Wyoming.One of the coal units was recently upgraded with state-of-the-art carbon capture technology, diverting emissions from production of about 240 MW of energy (enough for 200,000 households). The project, managed by two energy companies, American NRG and Japan's JX Nippon, was called Petra Nova, which means new oil in Latin. When she started working earlier this year, she became and still is the world's coal-fired power plant with carbon capture technology, with the ability to capture more than 90% of its emissions, about 1.6 million metric tons of carbon emissions each Construction cost $1 billion, of which $190 million came from the U.S. government. Among a number of setbacks, Petra Nova stands tall as a carbon capture project completed on time and within budget. Its success is due in part to the use of ready-made technologies that have been tested and proven. The failed Kemper project, on the other hand, tried to build his own set of technologies to convert coal into gas before doing carbon capture. However, the main reasons for its failure were due to reasons beyond technological innovation, such as the unexpected drop in natural gas prices. Petra Nova really has five projects in one, he said. Petra Nova does all five stages of carbon capture and storage (CCS): generating carbon dioxide, capturing emissions (which consists of two sides of the process), transporting it to where it will be stored, and injecting it deep underground and then controlling it. The step of the generation is simple. For centuries, we've been burning coal to generate heat. In some cases, heat is used directly, while in others it is converted into electricity. Part one of the capture step involves taking a mixture of gases in exhaust gases emitted by burning coal, usually about 10% carbon dioxide, 10% oxygen and 80% nitrogen, and separation of OT2. Carbon dioxide is slightly acidic, which means that it will react with the base. Neither oxygen nor nitrogen are acidic, so in this case, if you add a base to the process, it will selectively trap carbon dioxide from the mixture. Once other gases that have no greenhouse effect are released into the atmosphere, the second phase of capture begins: the application of heat breaks the link between the carbon dioxide and the base, creating a net stream of carbon dioxide that can be captured before it enters the atmosphere. The base can be reused to capture more carbon dioxide. The separation of carbon dioxide is necessary because of the next step: compression and transportation. Studies have shown that for the ideal storage of carbon dioxide gas must be compressed 100 times by atmospheric pressure. Squeezing gas that much requires a lot of energy. If carbon dioxide had not been isolated, a complete mixture of exhaust would have to be compressed, about nine times as much gas as the entire power plant. After CO_2 compression, Petra Nova is transported about 80 miles (130 km) through a pipeline built specifically to transport high-pressure carbon dioxide without leakage. Pipes may not seem like a big deal, but many carbon capture projects don't take off because the power plants are too far from the injection sites, and no pipeline is already created. It's not cheap to build your own: industry experts Every mile of the CO_2 pipeline can cost up to $2 million in the Houston area. Finally, once carbon dioxide is transported through a pipeline, the gas is pumped underground, under a depleted oil field. The site was not chosen arbitrarily. Before the CO_2 injection, the oil field produced about 300 barrels of oil per day, down significantly from a peak of 52,000 barrels per day in 1970. Now production at the field has grown to about 4,000 barrels per day. Peter Nova's carbon capture unit, in front of a large coal-fired shop that powers the WA Parish power plant. Out of sight This is a huge increase in production thanks to a process called improved oil production, and it is the largest current carbon dioxide market. The oil we use to produce energy is usually found in a porous, rocky layer of the earth's crust. When the oil field is first discovered, initial drilling is easy. But once the first light charges are sucked out, oil companies must flood the field with water to push out more fossil fuels. Because water and oil don't mix, however, only a limited amount of common oil makes it to the surface even then. Compressed CO_2 solves the problem. The gas can get into the hard to reach the crack of the rocky layer and dissolve the oil there (just as the detergent removes stains from your clothes) by flushing more of it to the surface. Every time CO_2 is pumped into an oil field, about 20% of the gas remains underground. The rest comes back to the surface with oil. This CO_2 oil mixture separates, simply reducing pressure and allowing the CO_2 to bubble out of sticky black liquid. The carbon dioxide is then re-caught and returned to the field. After all, all greenhouse gas is sequestered. Improved oil production now provides the largest revenue stream for companies that capture carbon dioxide. If oil prices rise, it may even profit from the dumping of carbon dioxide. This may not seem like a solution to climate change. After all, investing in this technology can really help the fossil fuel industry. But it has the potential to make a huge dent in our CO_2 emissions. Oil companies currently pump about 68 million metric tons of CO_2 into U.S. oil fields each year. Only 25% of this comes from the capture of emissions from human sources. The main source of carbon dioxide to increase oil production today is - I'm kidding, you non-natural CO_2 deposits. In other words, oil companies are extracting carbon dioxide just as the world is desperately trying to production so much. It is now cheaper to extract underground carbon dioxide in one part of the country (where it is available as a pure gas) and then transport it to it hundreds or thousands of miles than go through the entire five-step process needed to capture it from human sources. And oil companies won't stop doing that until we stop using oil, which won't happen anytime soon. If others follow the path Peter Nova has laid out, however, to provide man-made CO_2 at a similar or lower price, oil companies will give up using geological sources in a heartbeat. We have been injecting carbon dioxide underground since the 1970s, and we know a lot about oil and gas fields, so scientists have a good idea of the geology in the game. U.S. regulations require that injections of man-made carbon dioxide in oil and gas fields are constantly monitored for any possible leaks, and there is strong evidence that this is a relatively safe feat of technology. After all, it could be several years, or decades, depending on how quickly the world adopts CCS- we will exhaust the storage capacity of depleted oil and gas fields. Fortunately, carbon dioxide can also be stored in underground salt aquifers, which are water-sonic rocks saturated with salt water. There CO_2 is mixed with water and remains trapped underground. (The Sleipner project in Norway, which is run by Statoil, stored 10 million metric tons of CO_2 in salt aquifers between 1996 and 2008.) And CO_2 can also be stored in a widely available basalt rock, where the gas can mineralize into stone (as in the Icelandic Hellisheidi project). Peter Kelemen, professor of Earth and environmental sciences at Columbia University, warns that we still need to do more research on salt aquifers and basalt-type rocks before we start pushing all of our CO_2 emissions into them. But if proven, research shows that there is more affordable space for carbon storage than we will need for decades to come. Yet Petra Nova is one of 17 large-scale CCS facilities in the world, with only a handful more under construction. The world needs at least 200 facilities by 2025 to stay on track for zero emissions. The main reason why we don't have any more is because there is no long-term business model for CCS yet. Studies have shown that revenues from increased oil production can be a bridge to the creation of business models that make CSU more sustainable. However, not every project will be able to sell its CO_2 for use in improved oil production. For environmentally minded entrepreneurs, this demand for more CCS projects represents a great opportunity. Their task is either to convert carbon dioxide into products for which people are willing to pay, or to find a way to capture gas at a zero price. AP Photo/Susan BryanCatching S-shaped waveIsam Dyranih has always believed that technology can help defeat climate change. As head of venture capital for oil giant BP in the early 2010s, Dyrani invested in many clean energy start-ups. But he was disappointed with the pace of pace He is now CEO of the Global CO_2 Initiative, where he hopes to accelerate what he started by investing $300 million over the next 10 years in 300 clean energy startups. Investing now, Dairanieh believes, will position it well to take advantage of what can become a massive industry. The potential market for products made from carbon dioxide could be as much as $1.1 trillion by 2030, says Dairanieh. The potential market for products made from carbon dioxide could be as much as $1.1 trillion by 2030. In the last few years alone, hundreds of startups have sprung up in search of ways to convert carbon dioxide into new products. When Dirani launched the Global CO_2 Initiative in 2015, the $20 million carbon X-Prize went through the design proposals of 47 teams competing to create the most valuable carbon dioxide product. Since then, the contenders have been selected to 20 semi-finalists. Each has until February next year to build a prototype that can capture at least 200 kg of carbon dioxide a day for at least three consecutive days and convert it into useful products. Teams will use emissions from a coal-fired power plant in Wyoming to test their technology. We're looking for inventions that are daring, but perhaps, says Marcus Singles, CEO of the X-Prize.The X-Prize draws inspiration from the Ortega Prize, which in 1919 encouraged everyone in the world to try to complete the first non-stop flight between Paris and New York. After all, the competing teams spent more than $400,000 trying to win $25,000 (about $6 million and $375,000 in today's money, respectively). The winner, Charles Lindbergh, changed the commercial aviation industry forever when he made that first non-stop, transatlantic flight in 1927. Just two years later, more than 170,000 passengers flew across the ocean on commercial airlines. The rapid development of long-haul flights is not as extreme as it seems. Charles Sandstrom of Chalmers University of Technology notes that many technologies develop along the S-shaped curve, where progress is slow, then breakthroughs, and from that point on quickly moving forward until development reaches the upper limits of scientific possibilities. The Turtle team created the Carbon X-Prize because they believe that carbon dioxide conversion technologies are at an inflection point. Some companies already sell CO_2 products. Covestro (formerly Bayer Materials) in Germany offers mattress foam, partially made from carbon dioxide polymer, which got inside. Tuticorin Chemicals in India Capture Carbon Dioxide From coal and converting it into ash soda. Another startup I interviewed who did not want to be named because it is in the process of launching a product, is converting carbon dioxide into ethanol ethanol Make a liqueur. (Usually distilled alcohols are produced with ethanol produced by fermenting grains, fruits or vegetables, a process that actually releases a lot of CO_2.) And there is still a lot at the stage of development. Algoland in Sweden uses emissions captured from a cement plant to feed the algae and grow them faster than usual and then sell protein-rich algae as a feed additive for the animals. Carbon Engineering in Canada captures CO_2 from the air and develops the process of converting it into biofuels. Opus 12 in California has a laboratory prototype producing special chemicals made from carbon dioxide. Newlight Technologies, also in California, is in the process of commercializing plastic made in part with CO_2. In New Jersey, a startup called Solidia Technologies is working on a form of cement that absorbs carbon dioxide when it is installed in concrete. (You can read quartz's artistic story about Solidia.) Of course, the laws of thermodynamics will say that converting carbon dioxide into a product will require more energy than was produced when fossil fuels were burned to generate the same CO_2. But that doesn't make it a bad idea. Renewables will continue to become cheaper. In addition, wind and solar energy are intermittent in nature, producing less energy on windless or cloudy days. To ensure a reliable energy supply in those days, the total capacity of renewable power plants must be two to three times the amount of energy needed for actual use. On the other hand, there will be times when the world produces more wind and solar energy than we can consume. Using abundant renewable sources of cheap energy to convert CO_2 is no longer crazy, said Julio Friedman, a former deputy assistant secretary of energy and an expert in carbon management. It was crazy three years ago. It's not crazy now. (You can read an extended version of quartz's conversation with Friedman.) In search of breakthroughs, the Company estimates that new CO_2 products can store up to 10% of the world's annual emissions, about 4 billion metric tons of carbon dioxide. However, it still leaves a lot for us to capture and bury, and to do so, we need to figure out how to make the process cheaper. Ethan Novek won his first science fair at the age of 12; he received his first patent at the age of 16; and now, at 18, he runs his own company, Innovator Energy. Novek took the idea from a school project that won him awards at the International Science and Engineering Fair in 2015, and developed it into a technology he now believes can capture and bury carbon dioxide at $10 or so per metric ton, about 85% less than that Standard. Basic science has been tested in the laboratory of Yale University and published in a peer-reviewed journal; he recently moved to San Antonio, Texas to build a pilot plant. (You can read quartz's history of Novek.) About three hours east of the Antonio, another startup piloting what could be an even more revolutionary technology. A conventional gas plant, though better than coal, is still only 60% efficient. Net Power has built a $150-million facility in Houston, Texas, that uses some of the unique PROPERTIES of CO_2 to enhance overall efficiency. Better yet, because the plant uses clean oxygen to burn fuel, the exhaust contains only carbon dioxide and water. This means that after a little cooling and re-suppression, which require additional energy, CO_2 can be pumped underground. After all, Net Power gets about the same efficiency as a standard natural gas power plant, but with essentially free carbon capture. The 50 MW pilot plant, which will produce enough power to power 40,000 homes, is expected to start burning natural gas in early 2018. If successful, it would be the world's first fossil fuel power plant to produce zero emissions at no additional cost. (You can read quartz's story about Pure Power.) Efforts to capture carbon are cheaper than startups. Researchers are developing membranes that are essentially plastic sheets containing microscopic holes to allow most gases in the exhaust mixture like oxygen, nitrogen and argon to pass, while capturing much more CO_2 molecules without wasting as much energy as is needed for conventional methods. Others are working on a solid base for carbon dioxide capture, as opposed to the hard-to-process liquid bases commonly used today (including in Petra Nova). Conquering the mystery of the costconvention economy implies that we must allow technology to compete in the market and let the best win. But as the economist Nicholas Stern put it, climate change is the biggest market failure the world has seen. Most of these nascent carbon capture technologies, like other energy technologies, were born only from government funding. To get them to mature for deployment on a scale that could change our fight against climate change, they will need additional government assistance. One way to create a realistic CO_2 market is government regulations that limit how many of them can be thrown away. It doesn't have to be all or not- there are ways that the U.S. has successfully implemented before to work with the private sector to get it to where it needs to be. Take the case of sulphur emissions. The sulfur-containing gases emitted by fossil fuel power plants are the main cause of acid rain and toxic debris contamination. Public outrage over air pollution in the 1960s, the U.S. government adopted strong rules to reduce sulphur emissions. However, it is essential that these provisions be introduced in stages. First, the government has allocated grants to support early-stage research into technology that will scrub sulphur from fossil fuel fuels This has reduced the cost of these technologies by making them more acceptable to the private sector. The U.S. government then gradually tightened restrictions on the amount of sulfur-containing gases and created a cap-and-trade system that gave companies flexibility in their speed and scope. In the end, with the right legislative and regulatory support, the sulphur industry took off. Nicholas Stern says climate change is the biggest market failure the world has seen. When it comes to greenhouse gas emissions, one market policy is to set a price for carbon production. Economists have already thought about the concept of social carbon cost (SCC). A 2014 study, which published various SCC models, found that, conservatively, every metric ton of CO_2 WILL today would cost the world $125 in future adverse effects. Depending on how much more we continue to emit, the SCC goes up or down. About one fifth of Norway's gross domestic product comes from the oil and gas industry. But the country also has a vast coastline and many glaciers that make it vulnerable to climate change. That's why Norway was one of the first countries to introduce a carbon tax in 1991.The impact of carbon prices was immediate. By 1996, Statoil, the state-owned multinational oil and gas corporation, had discovered that it was cheaper to capture and store carbon dioxide emissions from the Sleipner gas field than to pay the taxes it would have to if CO_2 had been invented into the atmosphere. Sleipner became the first large-scale project in the world to capture and store carbon, followed soon by the Snechwith gas field, also owned by Statoil. Collectively, these projects bury more than 1.5 million metric tons of carbon dioxide each year. In general, the carbon tax has added rocket fuel to Norway's transition to a zero-emissions country. In 2016, the country's parliament announced that it was advancing its emissions targets for 20 years; it will now try to achieve net zero emissions by 2030, not by 2050. And that was with a tax of just about $70 per metric ton of carbon dioxide, much lower than the SCC's $125.Today, carbon taxes exist in some form in more than 15 countries around the world. The UK introduced the price of carbon flooring in 2011. Now, six years later, the country that led the industrial revolution at coal-fired power is on the verge of eliminating the use of dirty fuel. But perhaps the most instructive example of how carbon taxes affect emissions comes from Australia. When the country announced it would levy a tax in 2012, its emissions The new policy will come into effect. For nearly two years, emissions continued to swing until a political shake-up led to a new government that changed policy at the end of 2014. Immediately, CO_2 emissions began to rise again; by 2016 they're they 2012. Bring in parity the Paris climate agreement's goal of achieving zero emissions has intensified interest in carbon capture technologies around the world. Canada has the majority of CCS projects except the U.S., with three in operation and two to run in 2018. Norway has some of the longest after the U.S., and plans to build more in the near future. Australia will soon be home to one of the world's largest ccS plants: the Gorgon project, which is expected to be launched in 2018, will separate carbon dioxide from natural gas and bury almost 4 million metric tons of CO_2 a year. India plans to fund at least one carbon capture project by 2020. Finally, although China does not currently have completed large-scale USC projects, it has more of them in the planning phase than any other country. (You can read the quartz feature story on China's efforts.) However, the world continues to look at the U.S. successes in carbon capture. There's one thing many of the innovations mentioned in this article have in common: the U.S. Department of Energy (DOE). The Department has provided Petra Nova with grants to build the first coal-fired power plant with USU, Solidia Technologies to assist in research, Newlight Technologies, helping to build up its technology, and Opus 12 in the form of laboratory facilities. Ethan Novek is currently applying for a DOE grant. So it's important what the U.S. leadership thinks about climate change. Leadership is of paramount importance, a former U.S. government official told me. Because he decides priorities for the country. Deputy Secretary Steven Chu, the Department of Energy focused on solar energy, energy efficiency and biofuels. When Ernest Moniz took over the job, the department shifted toward nuclear power, electrical sustainability and USU. It is unclear what current ME Secretary Rick Perry wants. On the one hand, he was happy to be at the ribbon-cutting ceremony for Petra Nova. On the other hand, he doubted that human-caused carbon emissions were the main cause of climate change. (They are. Perry's boss, Donald Trump, is behaving even more unpredictably. On the one hand, Trump promotes clean coal (even if he doesn't understand what that means). On the other hand, he wants to cut the budget of the Office of Fossil Energy in the DoE, which is responsible for financing carbon capture technologies. Between 2010 and 2016, the world spent $2.3 trillion on renewable energy and only $10 billion on UCH. The United States continues to be a world leader in carbon capture technologies. The early onset of increased oil production in the country created industry expertise in technology and led to the creation of the largest world network of CO_2 pipelines (more than 4,000 miles, or 6,400 km, long). This investment in infrastructure and technology has helped the U.S. oil and gas industry to remain among the Valuable. But the U.S. and the rest of the world need to do much more, and quickly. Between 2010 and 2016, the world spent $2.3 trillion on renewable energy, thanks in large part to government subsidies for the renewable sector (e.g. Germany insists on solar panels). According to the International Energy Agency, CCS received only $10 billion in investments during the same period. So it's no surprise that the Global CcS Institute, a not-for-profit group funded by governments and corporations, calls for climate change policy parity: If we want to save the world, the organization argues we must provide the same incentives for any technology that reduces carbon emissions. Vote for your mindThe term pure coal is a huge problem. It masks the fact that coal is a dirty source of energy. Modern so-called clean coal technologies virtually eliminate sulphur and mercury emissions, but do not reduce carbon emissions. And the use of coal seriously harms our fight against climate change. At the same time, coal has brought electricity to about 1.6 billion people for the first time in the last 20 years. And if we care about the development of all people, our energy will be better spent reducing emissions rather than being religious about a certain fuel. The trouble is that environmentalists are ingesting clean coal with USU. If the world is to reach zero emissions, we will need to apply CSU not only to coal-fired power plants, but also to natural gas plants and then to every carbon-emitting industry. In other words, CCS really isn't about coal. We can't afford this confusion anymore because time is running out. Ultimately, regardless of whether THE 1S is deployed, people who, through their elected governments, can push for the right policies. There's a perception around CCS that it adds a burden, as opposed to it reaching a goal. That has to change. That's why perception matters. Think about what's going on with nuclear power around the world. Since the Fukushima accident in 2011, a survey of 23,000 people in 23 countries has shown a sharp decline in people's appetite for nuclear power, a near-zero source of energy. No one died or became ill with radiation as a result of the disaster. The Japanese government's response was to take on the worst, and the panic that followed spread the fear of radiation around the world. Germany, which was previously a champion in nuclear power, has been involved in coal-fired power plants after implementing a policy to limit the use of nuclear energy. The result is an increase in the country's emissions in recent years, not a drop, as it has been in most of the richest countries of the world. The concept of pure coal has also shaped the misperceptions of USus. Also, even many of those who understand that differs from pure coal, do not support it because of the natural human bias sideways not a reduction. CCS does nothing new. You just don't have the emissions, said Julio Friedman, a former DOE employee. There's a perception around CCS that it adds a burden, as opposed to it reaching a goal. That has to change. The point is how people should think about CCS best done by Peter Kelemen, who told the story at the Columbia Global Energy Summit held this April. Around 1820, London became the largest and possibly the most important city in the world. It was not only the capital of Great Britain; it was a place from which the rulers of the empire controlled almost half of the world's population. But London, in a sense, is still a backwater - it lacked a central sewerage system. If you were poor, you threw it down the street, Kelemen told the audience. If you were rich, you had a pipe that took him to the cesspool. Jon Snow, now known as the father of epidemiology, conducted a study that showed a link between these cesspools and at least three cholera outbreaks that killed more than 30,000 people in the first half of the 19th century. To add to the troubles, most human waste eventually found its way into the thames. I can confirm that the abusive smells, even in that short whiff, were the most head-and-stomach-baking character, Charles Dickens wrote in a letter to a friend in 1857.Scientist Michael Faraday dropped pieces of white paper into the river to check the degree of opacity. Then, in 1858, there was a summer when it didn't rain, Kelemen continued. The Thames dried up, and the stench grew stronger. It was called the Great Stink. The queen and the royal court left London; MPs discussed moving to Oxford. Fortunately, instead of leaving, they passed legislation to do something. They dug up all the major roads in the world's largest city, and they installed a central sewer over the next 10 years, Kelemen said. It costs about 2% of GDP, and even today the maintenance of sewerage costs about 1% of GDP. No one doubted that it was worth it. As long as people think throwing CO_2 into the air like throwing poop in the street, we're not going to spend what it's worth. With 2% of global GDP, we can solve the CO_2 problem. As long as people think throwing CO_2 into the air like throwing poop in the street, we're not going to spend what it's worth. The long-term economy of UKus, framed in this way, seems not only feasible, but also highly reasonable. The International Energy Agency estimates that by 2050 the world should be burying at least 6 billion metric tons of CO_2 per year. Although Petra Nova won't say this, experts estimate the cost of carbon capture in the project at about $60 per metric ton of CO_2. That's half the social cost of not capturing the same carbon. Peter Knox's spokesman says there were companies to build the second block, the costs will be at least 20% lower than the first project, thanks to the lessons learned. Even with a conservative number like $60 per metric ton, the whole world will have to pay to start making the CO_2 problem go away today at $360 billion 2017.In. Last resortIf people don't change their minds about CCS and governments don't invest to make CCS rollout on a large scale a reality, the world will soon exceed the carbon budget needed to keep global temperature increases below 2 degrees Celsius. Some models suggest that we are already on track to cross this point, and the world will have to turn to some form of direct air capture technology currently being tested on a modest scale in Iceland. To suck carbon dioxide out of the air at levels to stop global temperature rise, we need to deploy hundreds of millions of machines currently operating at the Hellisheidi plant. It's a terrible prospect. CCS may seem expensive now, but direct air capture in the second half of the 21st century will cost many times more. Reason for simple physics: CCS occurs in a source of emissions that typically contain more than 5% of the carbon dioxide in the exhaust gas mixture. The concentration of CO_2 in the air is only 0.04%-100 times more diluted. Much more energy will be needed to pull carbon dioxide out of the air, meaning there is a lot more money. The most recent estimates suggest that the cost of direct air capture could be as high as $600 per metric ton - nearly 10 times the cost of carbon capture technology today. This economic impact will hurt much more than the deployment of carbon capture on a large scale today. But even that can't hurt as much as uncontrolled climate change. Latest projections show that once 2027, the cost of raising temperatures will be $360 billion a year for the U.S. alone. The damage to the rest of the world can be four times greater. Prevention is better than cure. And for our dying planet, or better than doing nothing. This article was edited by Elijah Wolfson and produced by David Janofsky. Janofsky. mitigation measures to climate change pdf. adaptation and mitigation measures to climate change. mitigation measures to reduce climate change. mitigation measures to curb climate change. mitigation measures and adaptive responses to climate change

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